FALLS OF ROOF:
THE NO. 1 KILLER IN BITUMINOUS-COAL MINES

BY J. J. FORBES, T. L. BACK, AND H. F. WEAVER

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INTRODUCTION

The investigation of major and minor coal-mine disasters has been a routine function of the Bureau of Mines since its inception in 1910, and the facts obtained during such investigations have been used as a basis for determining the precautions that the personnel of many mines are observing to prevent similar occurrences. The Bureau has conducted extensive research on roof-control problems, but a comprehensive study of fatal roof-fall accidents was not attempted until February 10, 1950, when the policy of investigating all coal-mine fatalities was approved by Bureau of Mines Director James Boyd. The investigations are being conducted by Federal coal-mine inspectors functioning under the provisions of the Coal Mine Inspection and Investigation Act of May 1941, Public Law 49, and reports covering the investigations are distributed to management, the State mine inspection agency, and representatives of the mine workers organization having jurisdiction at the mine.

SCOPE AND PURPOSE OF STUDY

This study covers the Federal investigation of 263 of the 315 fatalities from falls of roof, face, or rib that were charged to the bituminous-coal industry during the calender year 1950. The number of roof-fall fatalities investigated is recorded by States in table 1.

The information in the fatal-investigation reports was condensed and arranged in such a manner that it would be useful to officials of coal companies and of the mine workers' organizations in planning fut ture accident-prevention programs; to safety instructors, who must present material of personal interest so that the causes of accidents will be well known to the class members, and so the means to prevent them will not be forgotten quickly; to safety directors, inspectors, and supervisors, who need such information to better carry out their duties; and for discussions at meetings attended by those who are interested in coal-mine safety. The ultimate objective is to provide information that will be helpful in preventing roof-fall accidents.

CONCLUSIONS

During 1950, 67 percent of all fatalities occurring underground at bituminous-coal mines resulted from falls of roof, face, or rib. This fact again brands roof-fall accidents the "No. 1 killer" of mine personnel and further emphasizes that a major effort must be made to prevent this type of accident if the total number of fatalities is to be reduced to any appreciable extent. This record is a challenge to all the forces that are interested in forwarding safety in the coal-mining industry, including management, labor, and State and Federal inspection agencies; the problem is of such magnitude that any effort to eliminate it merits the wholehearted cooperation of all parties concerned.

The study revealed that 74 percent of all the roof-fall fatalities investigated resulted from accidents that occurred within 25 feet of the working face. It revealed, further, that three out of four fatalities in this zone resulted from accidents that occurred in the relatively small area between the last permanent roof support and the face, the average length of which was 13 feet. This is the most dangerous area in the mines and is the place where special attention must be focused. The study indicated that a great many of the accidents would not have occurred if a more intense application of roof-support measures well known to the industry had been carried out.

The average dimensions of 220 pieces of roof rock that fell and resulted in fatalities were 12 feet long, 8 feet wide, and 1 foot thick. The comparatively large average area of the falls indicates the great possibility of preventing their falling by the installation of a reasonable number of supports in the immediate face area.

It is significant that only one of all the roof-fall fatalities investigated resulted from a fall of roof that was bolted. However, seven other fatalities did occur in places where roof bolts were used, but failure of roof bolting was not involved. Four of these occurred while the victims were drilling roof-bolt holes without the use of conventional supports for temporary protection, and three occurred while the victims were loading coal inby the bolted area without benefit of some means of temporary protection from roof falls. Sufficient data are now available to prove that roof bolting is definitely an effective means of reducing roof-fall accidents.

One-half of all the face roof-fall fatalities investigated occurred in places where coal was loaded mechanically, though fewer men were engaged in such operations than were engaged in hand loading. This proves that mechanical operations are, to a considerable degree, the more dangerous from the standpoint of roof falls, notwithstanding that much closer supervision is possible and is maintained in such operations. These facts very definitely indicate management failure in providing sufficient roof support at working faces. It should be noted that any increase in concentration of employees due to mechanical loading causes an equal increase in the destructive potentialities of each fall of roof.

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Therefore, a comparable increase in expenditures on roof-support installations in such operations would be justified from an economic as well as a humane standpoint.

Based on the number of men employed, the roof-fall fatality record for hand loading was somewhat better than the record for mechanical loading. However, roof falls also accounted for by far the greatest number of fatalities in hand-loading operations.

Hand loaders, including those loading into cars and onto conveyors, suffered the greatest number of roof-fall fatalities. However it must be remembered that the number of hand loaders is greater than the number of persons in any other job classification. Loading- and cutting-machine operators and helpers rank high on the dangerous occupation list and account for 28 percent of the fatalities. Considering the relatively small number employed, timberman also had a very bad record, and fatalities in this group comprised 10 percent of the total. The fact that 21 of the roof-fall victims were foreman probably places this occupation in the "most dangerous" category and is an adverse reflection on the interest and competence of some supervisors in roof control.

Human failure was responsible for 89 percent of all the investigated fatalities resulting from falls of roof, face, or rib, and roof-fall accidents that, it is believed, could not be foreseen and avoided accounted for the remaining 11 percent. Management failure was responsible for 48 percent of all the fatalities; employee failure accounted for 29 percent; joint or undetermined failure, 12 percent; and unforeseeable accidents, 11 percent. The term "management failure" is used instead of "supervisory failure" because in many instances it was difficult to determine at what level in the chain of command the failure occurred.

Poor-quality supervision at the face-boss or mine-foreman level was responsible for 84 (32%) of the 263 roof-fall fatalities covered by this study; 43 (16%) of the fatalities resulted from management failure at an undetermined level, and it is very likely that some of the fatalities charged to employee failure to correct conditions that developed in the absence of the foreman would have been prevented if the official inspections of working places had been made more frequently during the shift.

This study indicated that there is a decided tendency to rely on roof testing as a substitute for roof supports, especially in areas where the roof is considered good. We have no intention of minimizing the importance of roof testing, and it should be adopted, studied, and constantly practiced in all mines. However, the judgment of the person making such tests should never be substituted for the minimum supports required in the systematic roof-support plan, but should be used to determine whether additional roof-control measures are needed. Moreover, any systematic roof-support plan that relies solely on roof testing by stating that "timbers or crossbars shall be set where needed" is not a true plan but is merely a continuation of the old practice of leaving the whole matter of roof support to the judgment of the foreman or employee.

The average period of mining experience of men killed in roof-fall accidents was 18-1/2 years, and the longest experience was 56 years. This fact does not support the theory, advanced by many of those engaged in the industry, that only inexperienced miners are affected by such accidents. On the contrary, it lends considerable credence to the theory of some that long and close association with dangers inherent in mining causes men to become inured to them, thereby creating an atmosphere conducive to accidents.

Inasmuch as the accidents that resulted in 234 (89%) of all the roof-fall fatalities investigated could have been foreseen and prevented, it is crystal clear that great strides toward the elimination of the "No. 1 killer" of mine personnel can be made, but only when all those who deal with mine safety make a more concerted and determined effort in that direction.

DIGEST OF INFORMATION REGARDING THE 263 BITUMINOUS ROOF-FALL FATALITIES INVESTIGATED

Fatalities by Location

1. One hundred ninety six (74%) of the 263 roof-fall fatalities occurred at the face, 48 (18%) on haulageways, and 20 (8%) at various other underground locations.

2. One hundred forty nine (76%) of the 196 face roof-fall fatalities occurred inby the last permanent roof support. In 61 (41%) of these cases, safety posts generally were set at the face as temporary supports, and in 88 (59%) of the cases no temporary supports of any kind were set inby the last permanent support. (See table 2 for a breakdown by States.)

The average distance between the last permanent roof support and the face (in those cases where the fall occurred at the face) was 13 feet. Reports that indicated no roof supports set in the working place were not used in determining this figure. The 220 pieces of roof rock that fell averaged 12 feet in length, 8 feet in width, and 1 foot in thickness. The largest piece was 103 feet long, 25 feet wide, and 3 feet thick; the smallest was 32 inches long, 18 inches wide, and 4 inches thick.

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3. Ninety eight (50%) of the 196 face roof-fall fatalities occurred in places where coal was loaded by machine. For the purpose of this study, machine loading does not include hand loading onto conveyors.

4. Two hundred ten (80%) of the 263 roof-fall fatalities occurred in solid workings, and 53 (20%) in pillar workings.

5. Eight (3%) of the 263 roof-fall fatalities occurred in places where roof bolts were installed as permanent supports. However, roof bolts were involved in only one of these fatalities, and in this case the bolting plan was not adhered to strictly; four occurred while the victims were drilling bolt holes without the use of conventional supports as temporary protection; and three men were killed while loading coal inby the bolted area without benefit of some means of temporary protection from falls of roof.

Fatalities by Cause of Accident

1. The study disclosed that management failure was responsible for 127 (48%) of the 263 roof-fall fatalities investigated. Fatalities were charged to this category under the following conditions:

a.	The foreman did not have a known bad roof condition corrected	47
b.	The foreman was aware of the large unsupported area under which men were working but did not have the condition corrected	33
c.	The foreman examined roof but did not detect bad condition	8
d.	The foreman visited the place just before the accident occurred but did not examine the roof	7
e.	Unnecessary exposure of foreman to obviously great danger	6
f.	Failure to examine roof and ribs along haulageways	5
g.	Crosscuts opened opposite each other	4
h.	Management allowed the place to be driven too wide (up to 60 feet)	3
i.	The foreman ordered men to work in inactive area without first examining the area	3

j.	Proper support material not supplied	2
k.	Underground supervision not provided	2
l.	The foreman required men to work in an area where a roof fall was imminent	2
m.	Failure to maintain straight pillar line resulted in a bump	1
n.	Roof bolting plan not strictly followed	1
o.	The foreman ordered men to recover timbers by hand from a mined-out area	1
p.	The foreman did not require the use of temporary supports while installing roof bolts	1
q.	The foreman did not correct a condition of inadequate clearance between timber and rolling stock	1

2. Employee failure was responsible for 76 (29%) of the 263 roof-fall fatalities investigated. These failures are broken down into the following categories:

a.	Employees did not correct a dangerous condition that developed in hand-loading places in the absence of the foremen	36
b.	Employees removed roof supports to allow free movement of equipment	8
c.	Employees did not correct dangerous conditions that developed in a machine-loading place in the absence of the foreman. (The roof was adequately supported at the time of the foreman's inspection.)	7
d.	Employees did not detect or support bad roof resulting from blasting	6
e.	Employees did not carry out instructions of the foreman	5
f.	Voluntary and unnecessary exposure to known great danger	5
g.	Intentional removal of supports to facilitate hand loading	3

h.	Careless or reckless operation of equipment	3
i.	Men working in mines in violation of a State closing order	2
j.	Employee did not replace posts knocked out by a machine	1

3. Joint or undetermined failure accounted for 31 (12%) of the 263 roof-fall fatalities investigated. These are broken down into the following categories:

a.	Victims were attempting to secure the roof that fell	15
b.	Rolling stock dislodged roof supports	11
c.	Victims were taking down loose roof, generally with a pick	5

4. Dangers that could not be foreseen accounted for 29 (11%) of the 263 roof-fall fatalities investigated. Following are some examples of conditions under which accidents were charged to this category:

a. The roof seemingly was well supported with crossbars set close together, and a piece of rock fell between them.

b. A fall started near the face and "rode out" as many as 6 crossbars set close to the face.

c. Kettle bottoms that could not be detected by sight or by sound test fell without warning.

d. The piece of roof that fell seemingly was well supported.

Fatalities by Occupation of the Victim When Injured

"Occupation," as used here, means the victim's regular job classification at the time he was injured.

1.	Hand loader (into cars or onto conveyors)	83
2.	Loading-machine operator or helper	44
3.	Cutting-machine operator or helper	30
4.	Timberman	27
5.	Foreman	21
6.	Shot-firer	13
7.	General duty face worker	10
8.	Motorman	8

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9.	Driller	6
10.	Boom and conveyor man	5
11.	Ventilation man	3
12.	Trackman	3
13.	Pumpman	2
14.	Continuous miner operator and helper	2
15.	Mechanic	1
16.	Electrician	1
17.	Shuttle-car operator	1
18.	Driver	1
19.	Safety committeeman while on inspection tour	1
20.	Mine examiner (fire boss)	1

Other Information Regarding Roof-Fall Fatalities

1. Forty four (22%) of the 196 face roof-fall fatalities occurred in places where the adopted timbering plan was being followed, showing its inadequacy.

2. Mines employing less than 25 men were nearly twice as dangerous as those in any other size group, based on the number of roof-fall fatalities per thousand men employed, as indicated below:

Size group	Fatalities investigated	Fatalities per thousand men employed
1 - 24 men	51	1.10
25 - 99 men	34	.58
100 - 299 men	79	.62
300 - 499 men	50	.67
500 men and over	49	.60

3. More roof-fall fatalities occurred between 1 and 2 p.m., 3 and 4 p.m., and 5 and 6 a.m. than at any other hour of the day, as indicated in the following tabulation:

Time of day	Fatalities investigated	Time of day	Fatalities investigated	Time of day	Fatalities investigated
7- 8 a.m.	9	3- 4 p.m.	16	11-12 p.m.	3
8- 9 a.m.	15	4- 5 p.m.	14	12- 1 a.m.	4
9-10 a.m.	17	5- 6 p.m.	11	1- 2 a.m.	1
10-11 a.m.	20	6- 7 p.m.	13	2- 3 a.m.	5
11-12 a.m.	22	7- 8 p.m.	7	3- 4 a.m.	2
12- 1 p.m.	14	8- 9 p.m.	8	4- 5 a.m.	3
1- 2 p.m.	32	9-10 p.m.	10	5- 6 a.m.	8
2- 3 p.m.	17	10-11 p.m.	10	6- 7 a.m.	2

The average age of the 263 roof-fall victims was 42 years, and their average length of service was 18.5 years.

5. Permanent crossbars were not spragged to prevent their being knocked out of position.

RECOMMENDATIONS

This is the first time in the history of coal mining that the Bureau of Mines or any other agency or person has assembled, on a nation-wide basis, detailed reports on the investigation of roof-fall accidents resulting in fatalities. A painstaking study was made of each such report for the purpose of obtaining information that may be beneficial to the industry in ridding itself of the roof-fall plague. The study reveals beyond a doubt that a much greater effort must be made to protect the workers from falls of roof. To insure the success of such effort, management must provide, first of all, sincere, competent supervisors, particularly for face regions, and the employees must cooperate fully in carrying out effective roof-support measures.

The following recommendations, based on information obtained through this study, are intended to reduce the incidence of roof-fall accidents in bituminous-coal mines:

To management:

1. Regardless of roof conditions, minimum standards for systematic roof support suited to the conditions and the mining system of each mine should be adopted and followed. The plan should show the minimum number and location of supports, either temporary or permanent, that shall be installed in the area near the face where men must work or travel, and the men should be instructed and required not to advance inby the last face support except those who are assigned to install the supports or to inspect the place.

2. The quality of supervision as it pertains to safety should be improved, and one method of doing this is proper education of each supervisor. The training should be conducted by management, and, when considered advisable, the safety education facilities of the United States Bureau of Mines or other organizations should be utilized to supplement management's program.

3. The roof, ribs, and face of each entry, room, or pillar where men work and the roof and ribs of passageways where they work or travel should be examined by a certified official as often as necessary to insure the safety of the workmen. Where dangerous conditions are found, they should be corrected promptly.

4. Crosscuts, rooms, and entries should not be opened opposite each other.

5. Crossbars should be spragged sufficiently to avoid the possibility of their being knocked out of position.

6. The bolting method of roof support should be adopted in areas where bolting is determined through experiments to be feasible and practical.

Controlled experiments to determine whether roof bolting is applicable should be made in conformance with the procedures that have been worked out by the Bureau of Mines. Bureau experiments are made under controlled conditions with auxiliary conventional supports during the initial experimentation. After a safe and economical method of bolting is determined, no deviation from this method should be made without undergoing a new experimental period. Also, if roof conditions change radically from those encountered during the initial experimental period, a new experimental period should be undergone.

To employees:

1. Employees should cooperate fully with management in developing a suitable roof-support plan and in obtaining compliance with it. In those places where roof supports are supposed to be installed by regular timberman, other employees should not enter or work therein unless the roof is properly supported. Under no circumstances should workmen accept less protection than the minimum set by the adopted plan.

2. In the absence of the foreman, the employee should be constantly alert for changes in roof conditions and should take immediate steps to eliminate any danger that might arise. When he is not sure what action should be taken, the place should be vacated and the foreman notified.

3. To better provide for his own protection and that of his fellow workmen, each employee should take special training in accident prevention. Such training is offered by the United States Bureau of Mines, by the management of some companies, and by other agencies.

4. A steel bar instead of a pick should be used to take down loose material, and employees should learn how to use a bar safely.

5. Roof supports should not be removed deliberately to facilitate loading or to allow free movement of equipment unless equivalent protection is provided by installing other supports.

TABLE 1. - Bituminous roof-fall fatalities investigated in 1950, by States

State	Number of roof-fall fatalities investigated	Total fatalities investigated (all causes)	Percent of total fatalities investigated (all causes) charged to falls of roof
West Virginia.	88	168	52
Pennsylvania..	56	77	73
Kentucky......	41	64	64
Illinois......	22	40	55
Virginia......	17	22	77
Ohio..........	8	17	47
Colorado......	6	8	75
Utah..........	5	7	71
Indiana.......	5	12	42
Tennessee.....	3	4	75
Alabama.......	3	11	27
North Carolina	2	2	100
Wyoming.......	2	5	40
Oklahoma......	1	2	50
Montana.......	1	1	100
Arkansas......	1	1	100
Maryland......	1	1	100
Washington....	1	1	100
Total....	263	443	59

TABLE 2. - Bituminous face roof-fall fatalities investigated in 1950, by States

State	Number of fatalities that occurred inby the last permanent support	Were safety posts set near the face?	
		Yes	No
West Virginia	49	17	32
Pennsylvania	30	15	15
Kentucky	22	10	12
Illinois	14	2	12
Virginia	10	7	3
Ohio	5	4	1
Indiana	3	-	3
Colorado	3	3	-
Tennessee	3	1	2
Utah	3	1	2
Wyoming	2	-	2
Maryland	1	-	1
Alabama	1	-	1
North Carolina	1	-	1
Arkansas	1	-	1
Washington	1	1	-
Total	149	61	88